

A STUDY OF THIN FILM
VACUUM DEPOSITED JUNCTIONS

Annual Status Report

on

NASA Grant NsG-340

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Submitted by:

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Charlottesville



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TABLE OF CONTENTS

<u>SECTION</u>		<u>PAGE</u>
I.	REPORT COVERAGE	1
II.	STATUS OF THEORETICAL RESEARCH	2
III.	EXPERIMENTAL RESEARCH.	4
IV.	ELECTRON TUNNELING (Addendum to material included in our Semiannual Status Report for the period ending June 5, 1965.)	6

SECTION I
REPORT COVERAGE

This annual report covers the period from December 5, 1964 to December 5, 1965. This research program is currently entering its fourth year of operation.

SECTION II

STATUS OF THEORETICAL RESEARCH

An extension of the theories of Schrieffer, Kingston, Greene, and others on the role of surface states in the control of the conductivity of thin films has been completed. The equations are transcendental in nature and therefore a comprehensive computer program has been set up to aid in the analysis. By means of this computer program an analysis of the conductivity of thin polycrystalline germanium films has been partially completed.

Preliminary results point to the likelihood of extensive trapping of electrons in the body of the film as well as on the surface. Such trapping throughout the body of the film would explain the lack of control a field effect plate has over germanium polycrystalline films. On the other hand, polycrystalline films of cadmium sulfide do exhibit a variation in electrical conductivity by means of a field effect plate. In the hope that a comparison of the physical electronic properties of films of Ge and CdS will yield basic information on the transport mechanism in polycrystalline films, the following steps are currently being initiated.

1. The computer program just mentioned will be used to analyze the CdS films. The theoretical results for Ge and CdS films may be compared.
2. Film of CdS will be deposited under carefully controlled conditions identical to those conditions under which Ge films have been deposited.

By comparing the properties predicted by theory with those obtained experimentally we hope to be able to answer some of the questions about transport phenomena in polycrystalline films of semiconducting material. The results obtained could be of great importance in the design of practical field effect transistors and transducers.

A certain amount of theoretical study on electron tunneling in thin oxide films has been in progress. In particular, an effort is being made

to satisfactorily account for the two components of current often encountered in thin film tunnel devices. The true tunnel current may be accompanied by a thermionic current which arises from Schottky enhanced emission. The relative magnitude of each component of current depends to a large degree upon the microstructure of the two conducting plates and of the insulating film which separates them.

It is felt that any useful analysis of experimental data on electron tunneling must not only take into account both of these components of current but, moreover, an attempt must be made to determine what percentage of the geometrical area of the tunnel sandwich is effective for true electron tunneling and what percentage is effective for Schottky thermionic emission. We believe we are very close to developing an acceptable method of solution to this problem. As part of the analysis it was necessary to solve the three electron tunnel emission equations due to (1) Bethe and Sommerfeld, (2) Holm, and (3) Fowler and Nordheim for various insulating film thickness, applied voltage, and surface work function (metal electrode to insulating film). This method was discussed in detail in our last Semiannual Report No. EE-4012-104-65U and will not be reviewed here. However, additional charts of solutions to the tunnel emission equations have been prepared and are included in this report (see Section IV).

SECTION III

EXPERIMENTAL RESEARCH

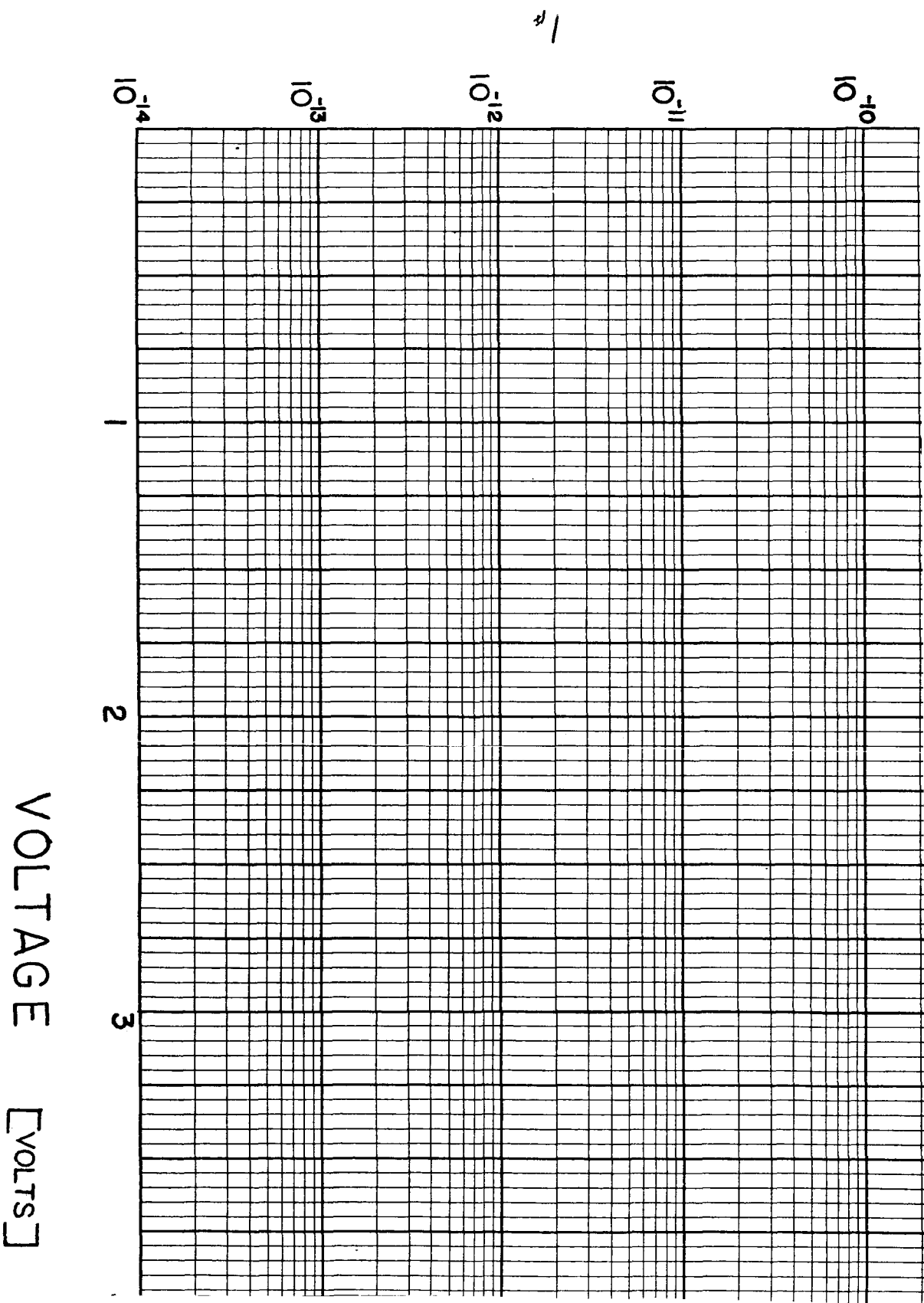
Currently four closely related areas of experimental research are in progress:

1. Field effect transistors employing CdS films are now being deposited with two goals in view. First, as mentioned in Section II on Theoretical Research, we hope to be able to compare the physical electronic properties of polycrystalline Ge and CdS films in the hope of learning more about the basic transport mechanism in such films. Second, we are attempting to form reliable vacuum deposited thin film field effect transistors.
2. Electron tunneling devices consisting of vacuum deposited gold-silicon monoxide-gold sandwiches have been made and are currently being evaluated. We have found that the extreme care which went into the design of the vacuum deposition system has made it possible for us to consistently turn out reliable tunnel devices. Additional research plans call for the incorporation of metallic whiskers on the cathode of these tunnel sandwiches. Some experimental research has been carried out along these lines but it is too early for any estimate of whether the idea will prove fruitful as a method of fabricating new devices.
3. Microwave bolometers and associated thin film passive elements (including Faraday rotators) for microwave systems will be in the experimental stage in late January. The University of Virginia has made additional funds available as well as the support of an additional graduate student. With this additional support a second ultra-high-vacuum film deposition system has been assembled and is currently being tested. This second system will greatly relieve the burden on our present system. (It is interesting to note that the present vacuum deposition system has operated almost continuously for the three years since its construction during the first year of our NASA grant!)

4. Thin film magnetometer research has reached the experimental stage. Again, the additional vacuum deposition equipment will permit this work to now proceed at full speed.

SECTION IV ELECTRON TUNNELING

The attached sheets comprise additional electron tunneling information to that supplied in Section VII of our Semiannual Report for the period ending June 5, 1965.



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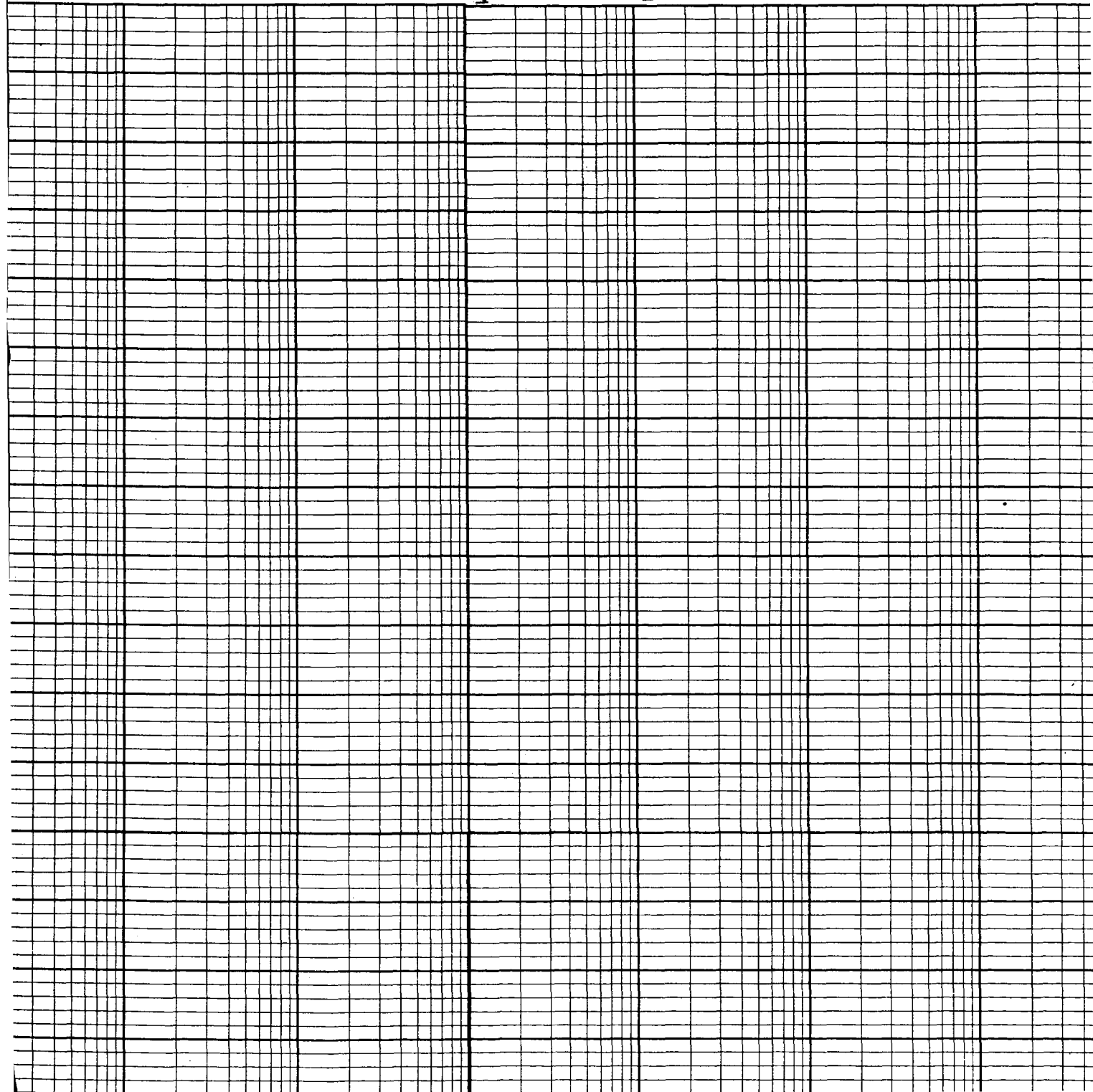
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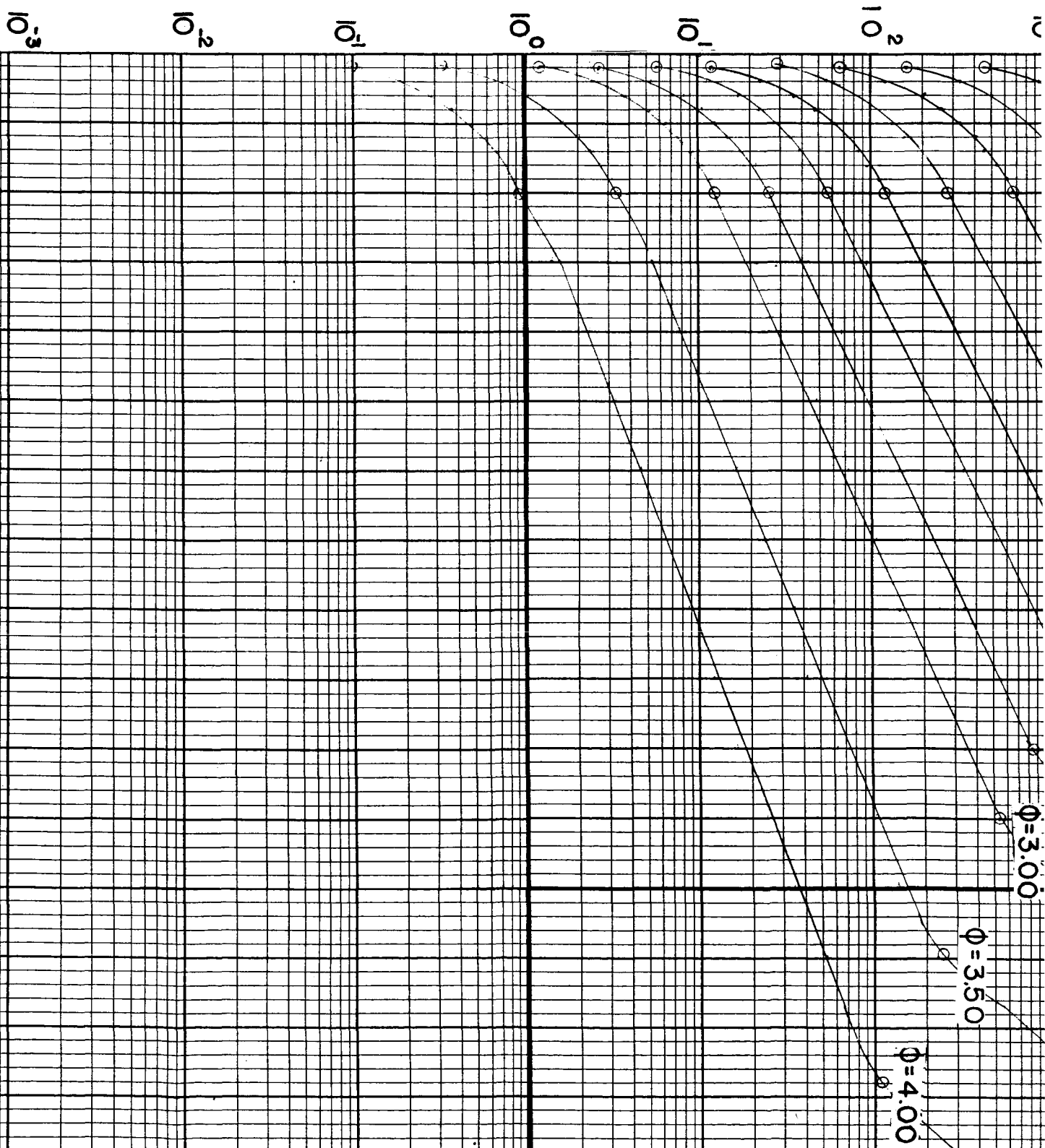
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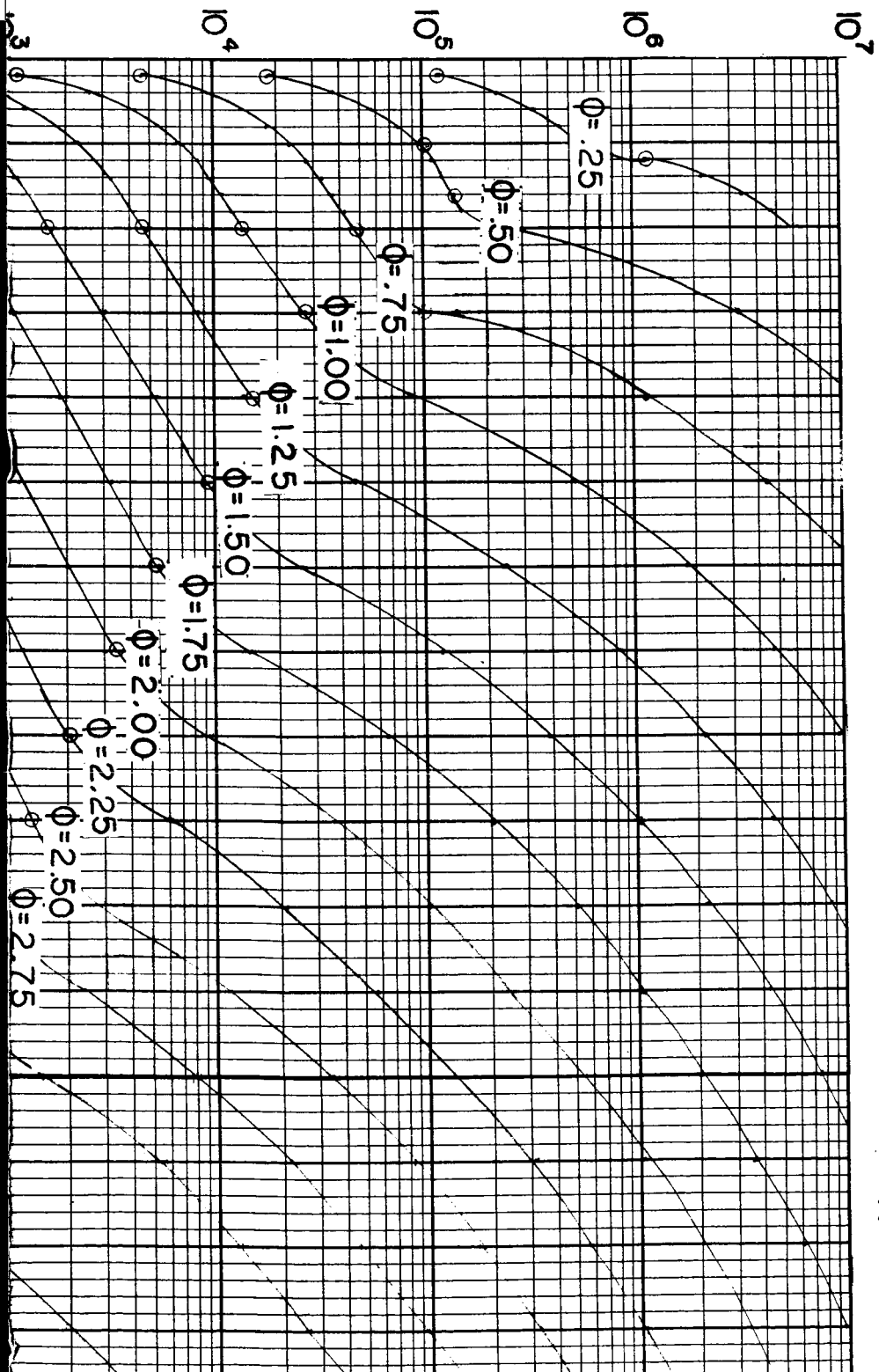


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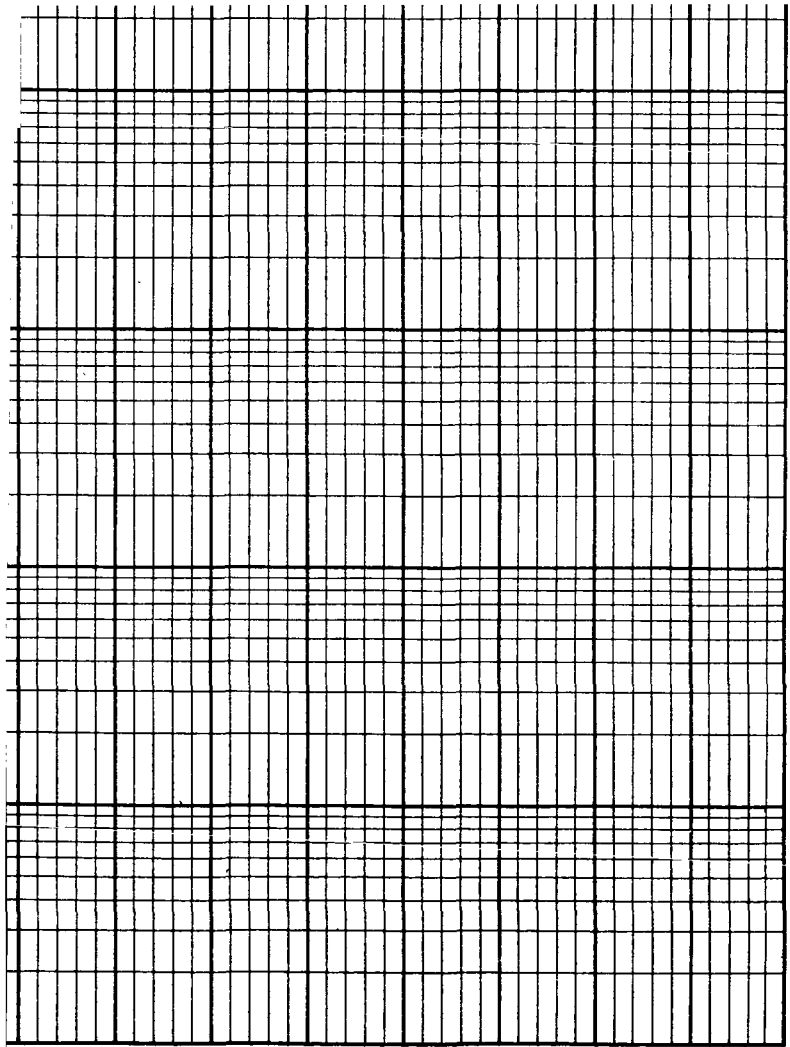
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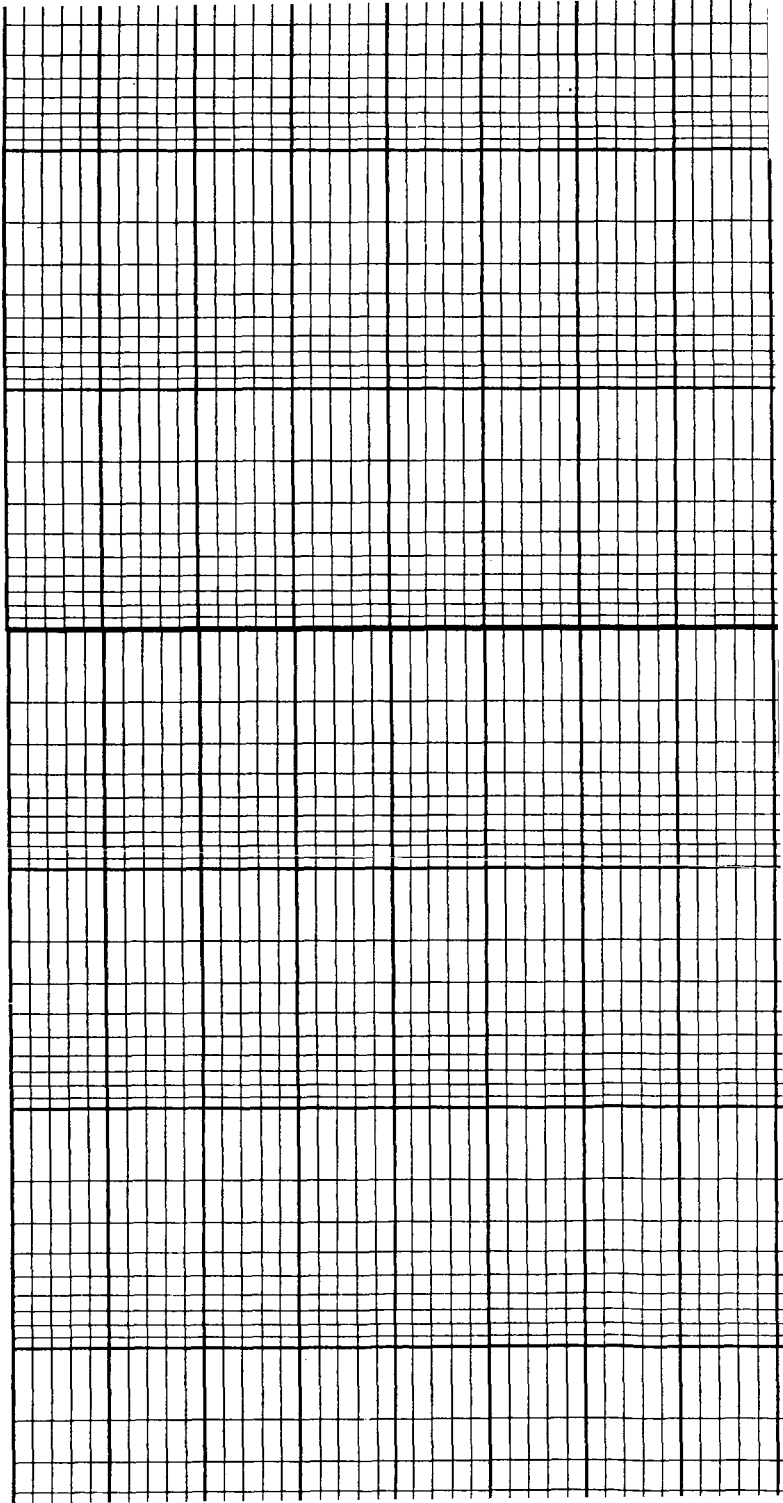
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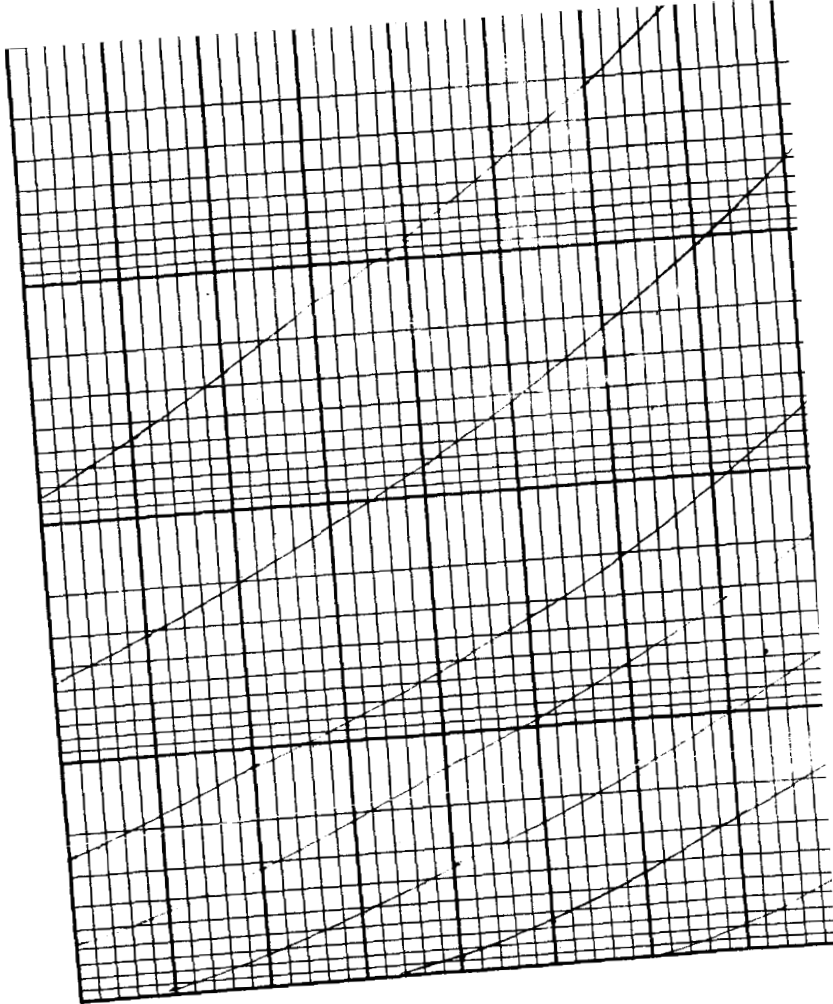
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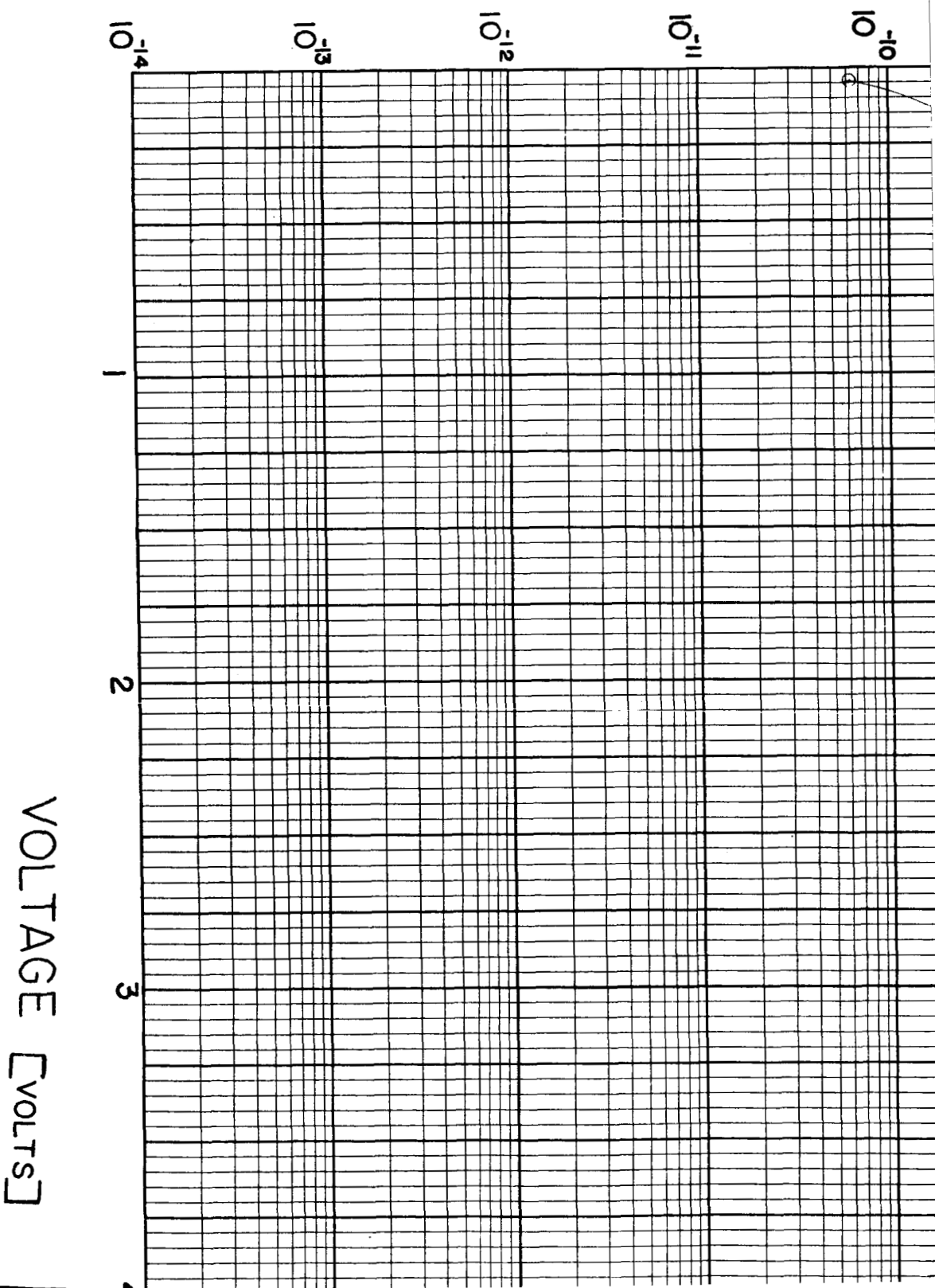


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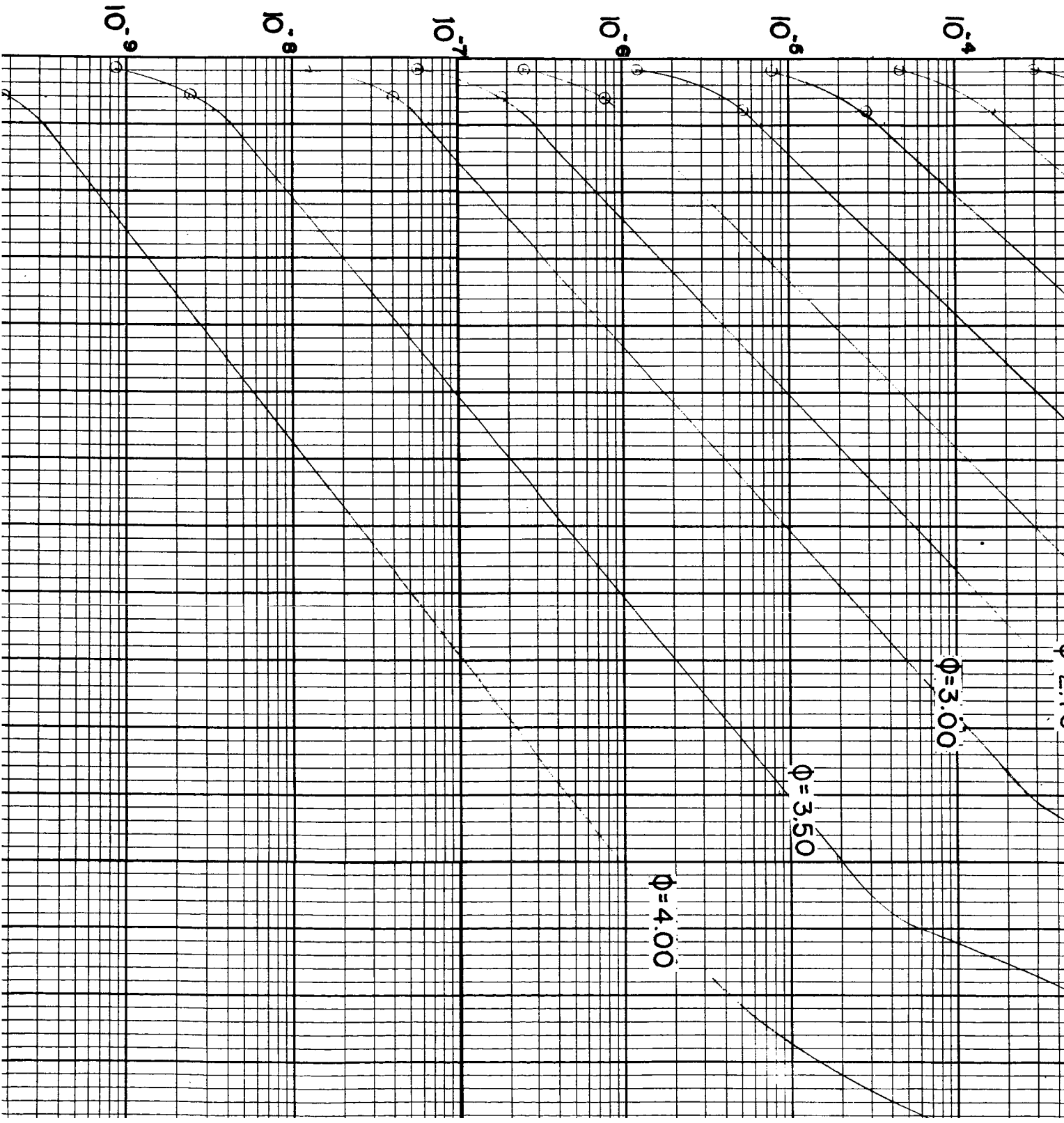


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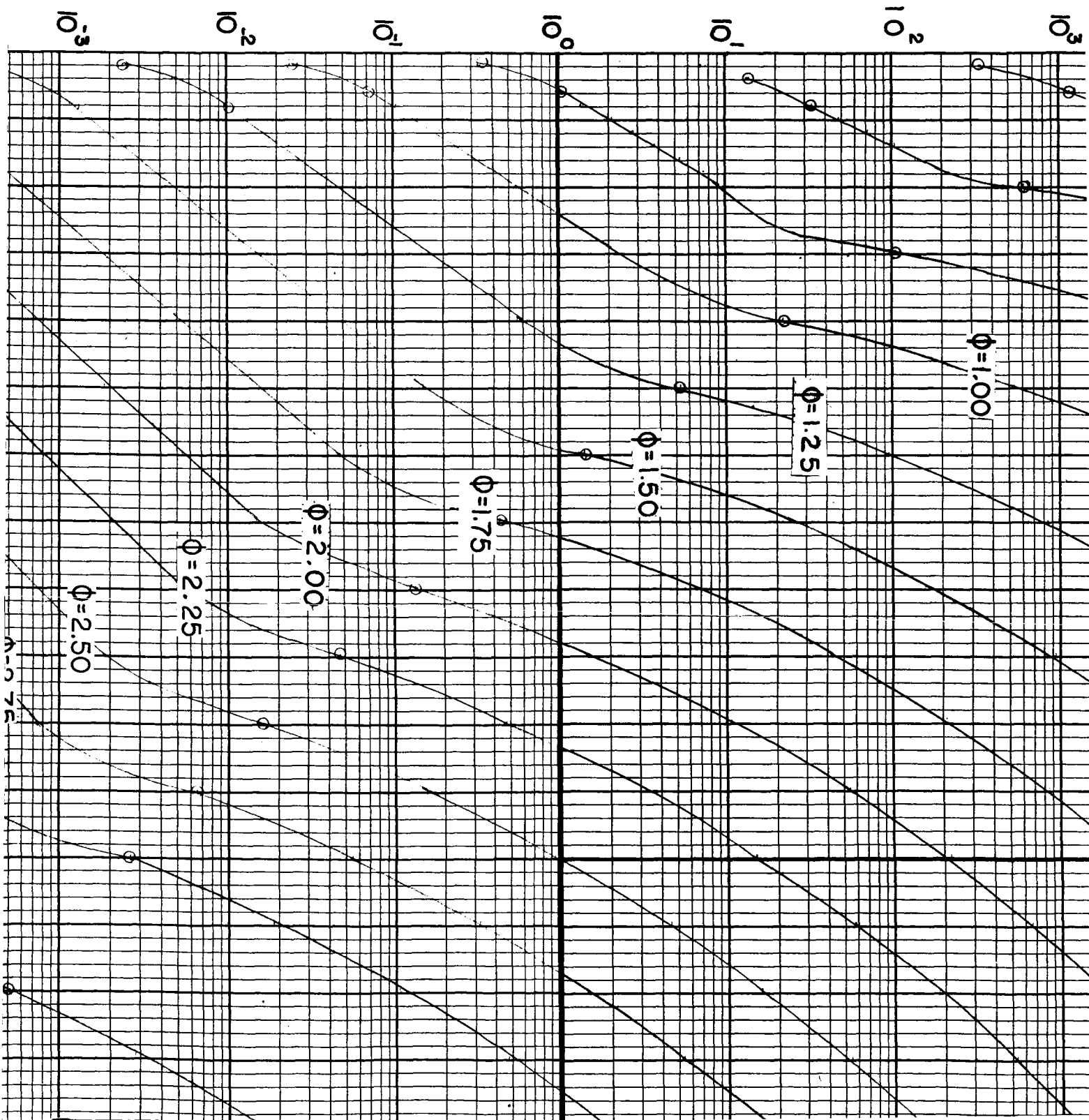


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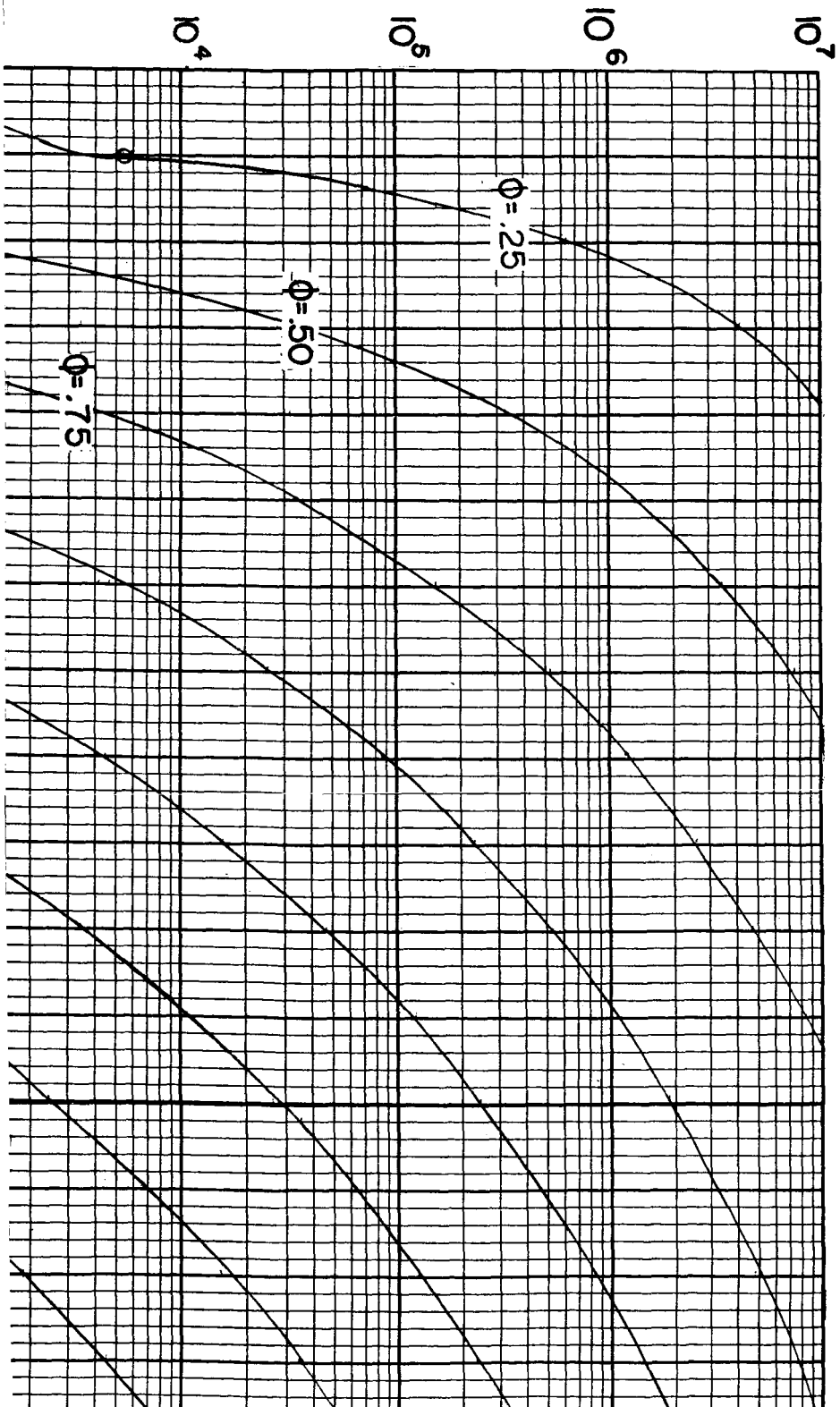
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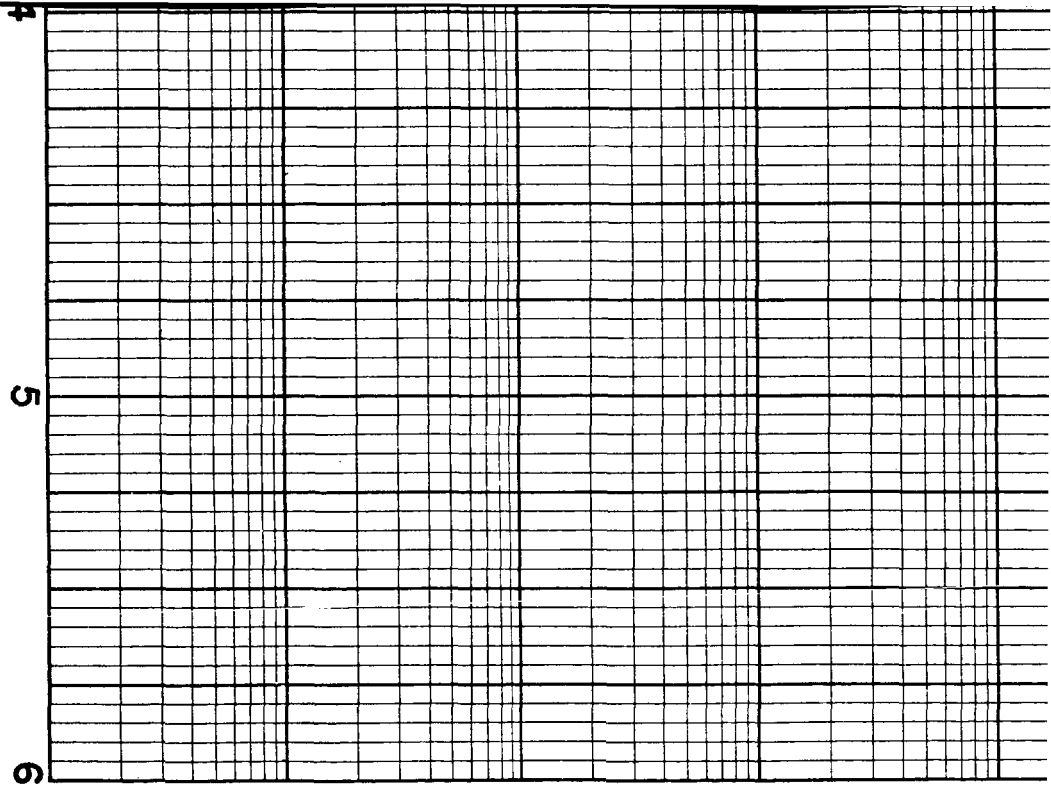


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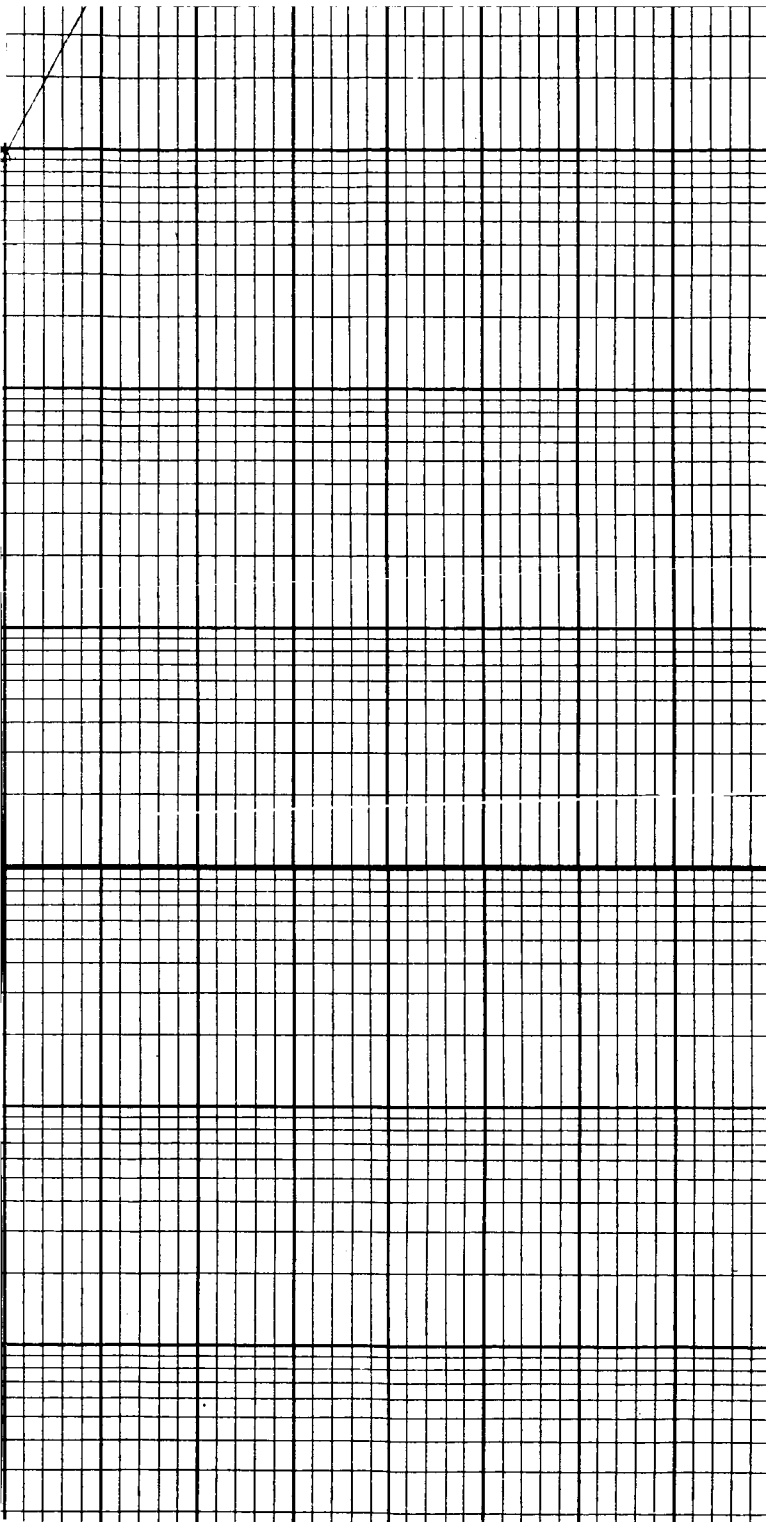


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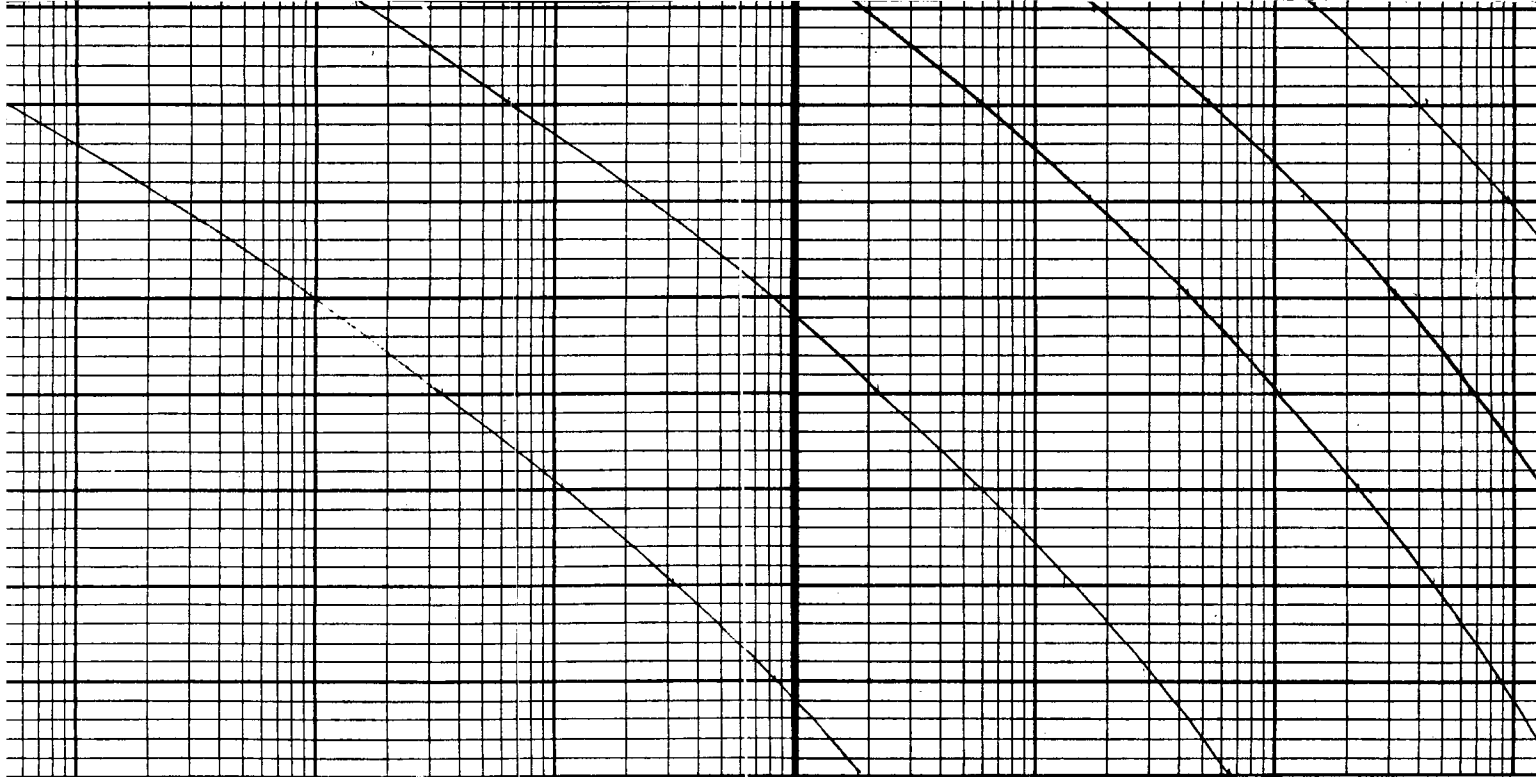




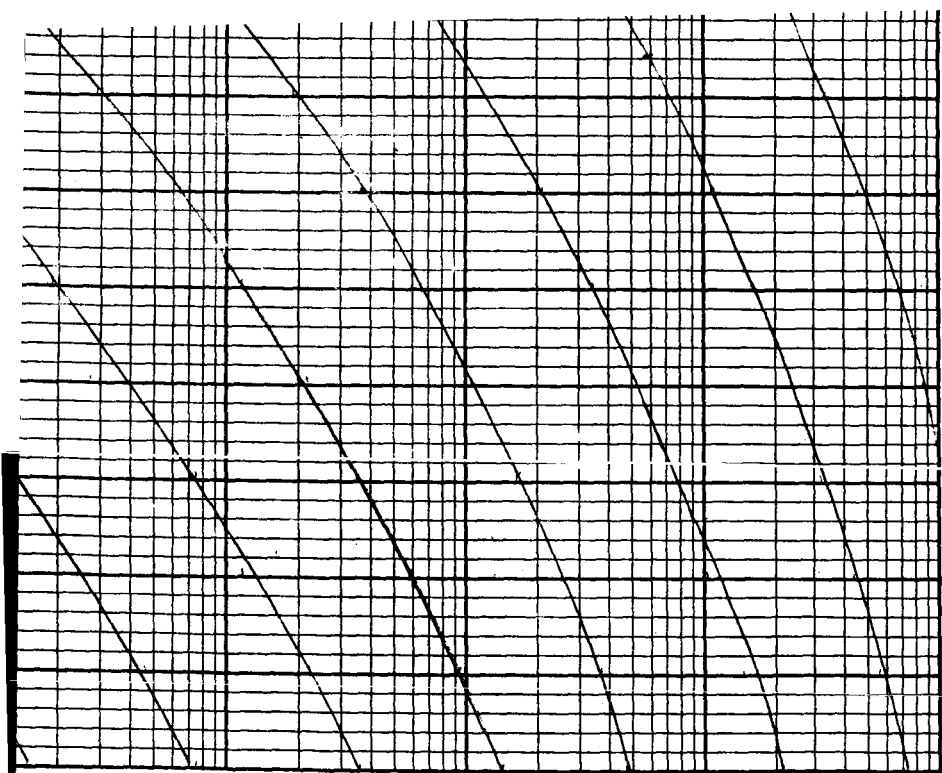
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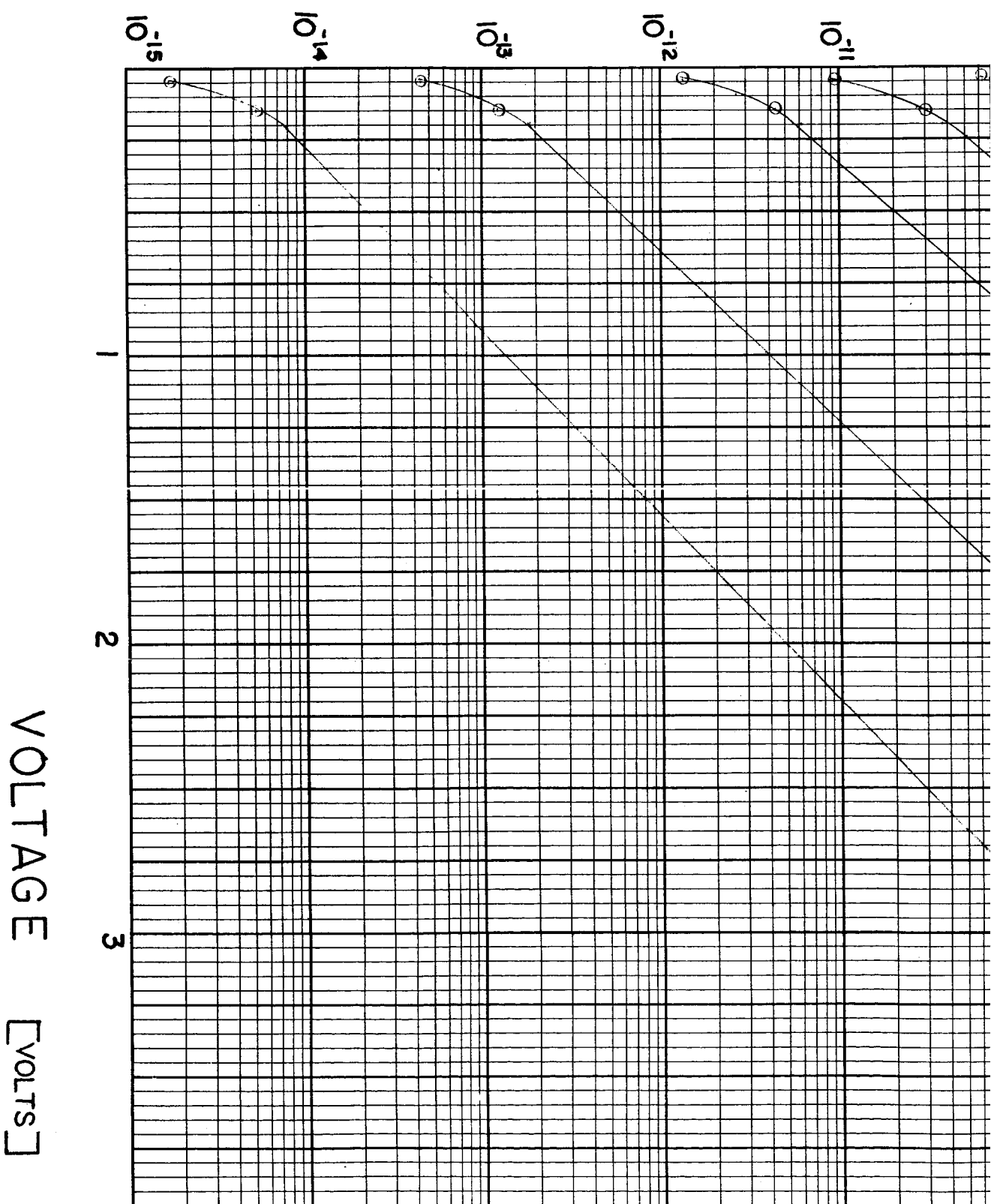


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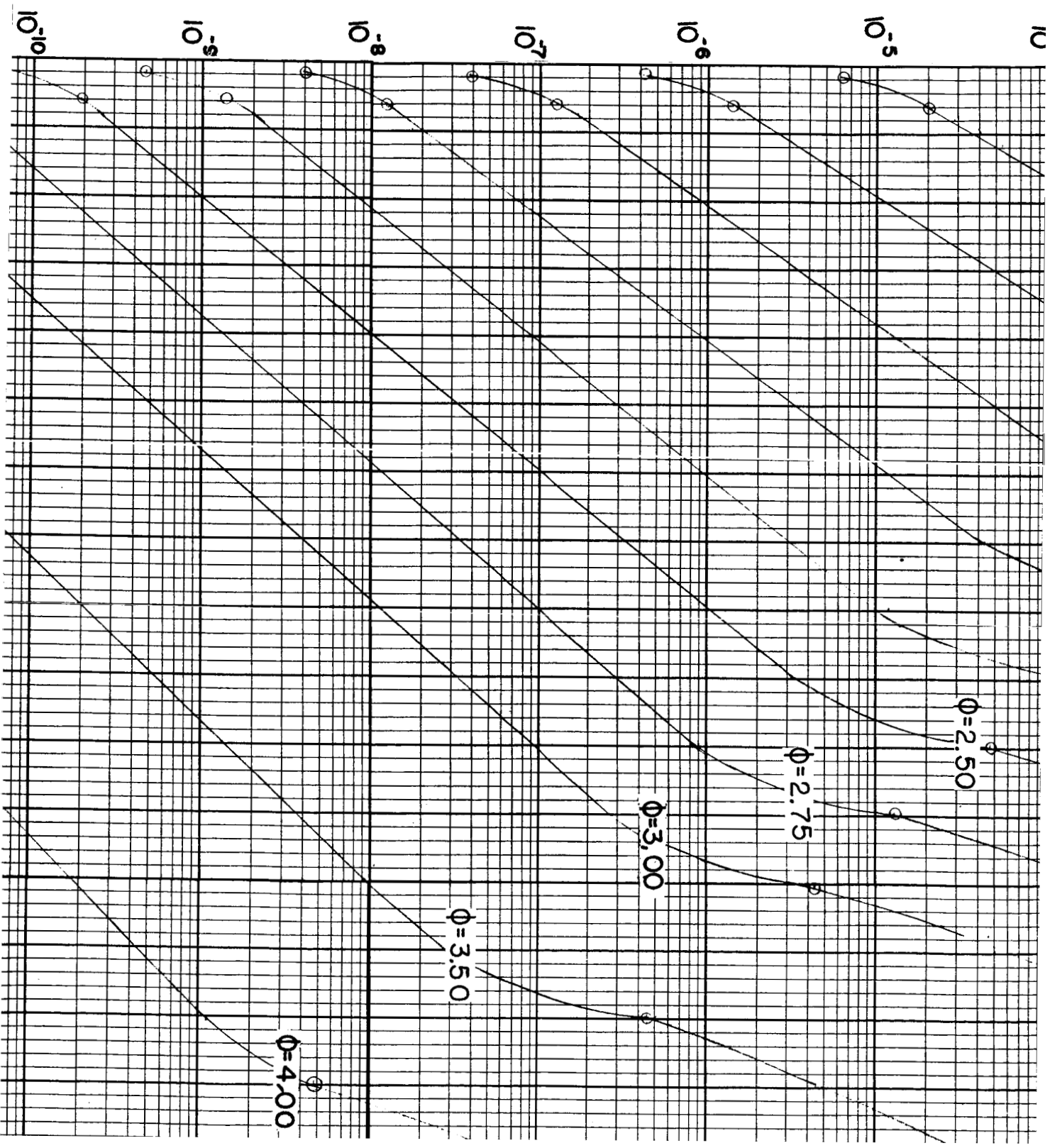
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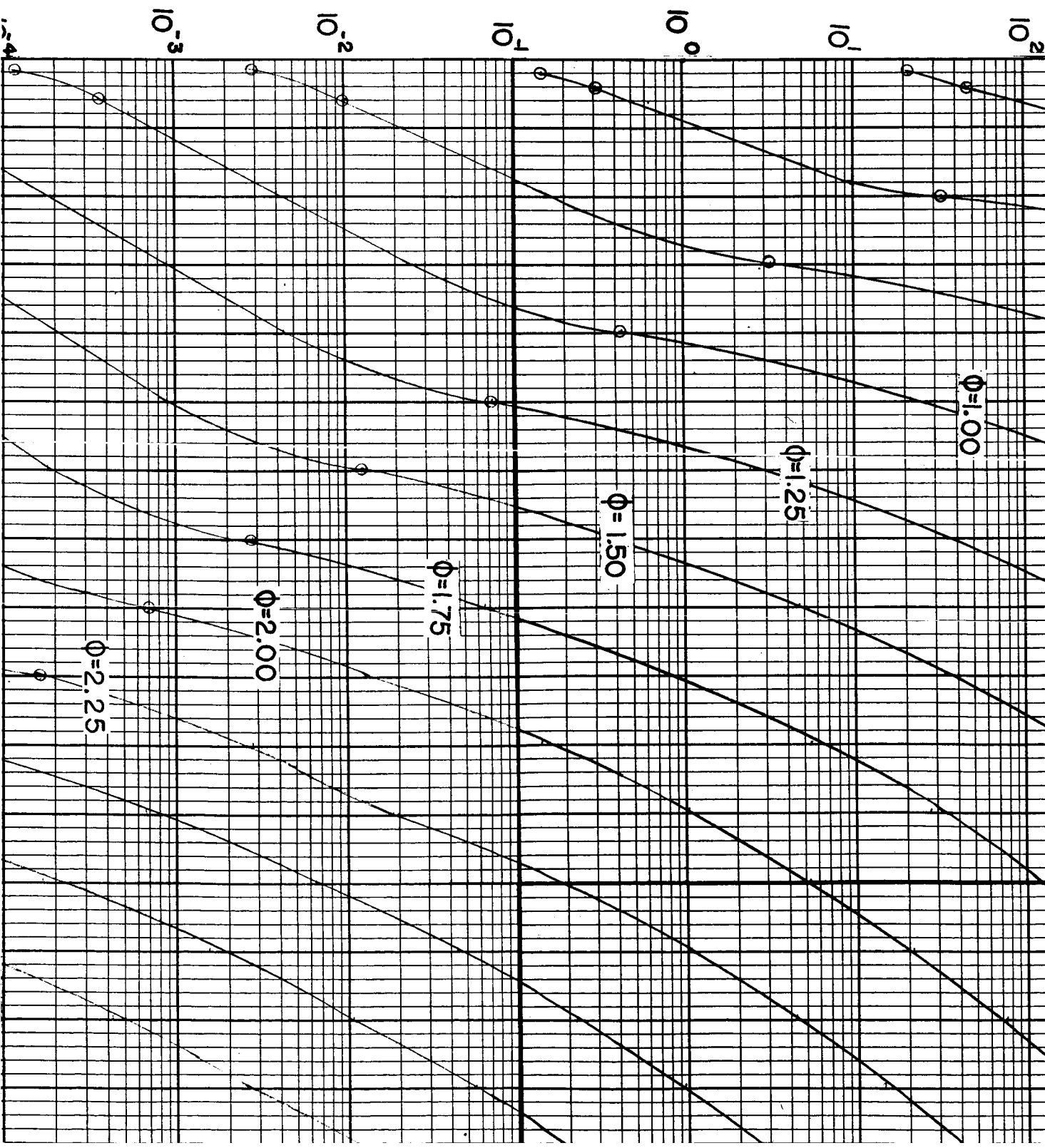
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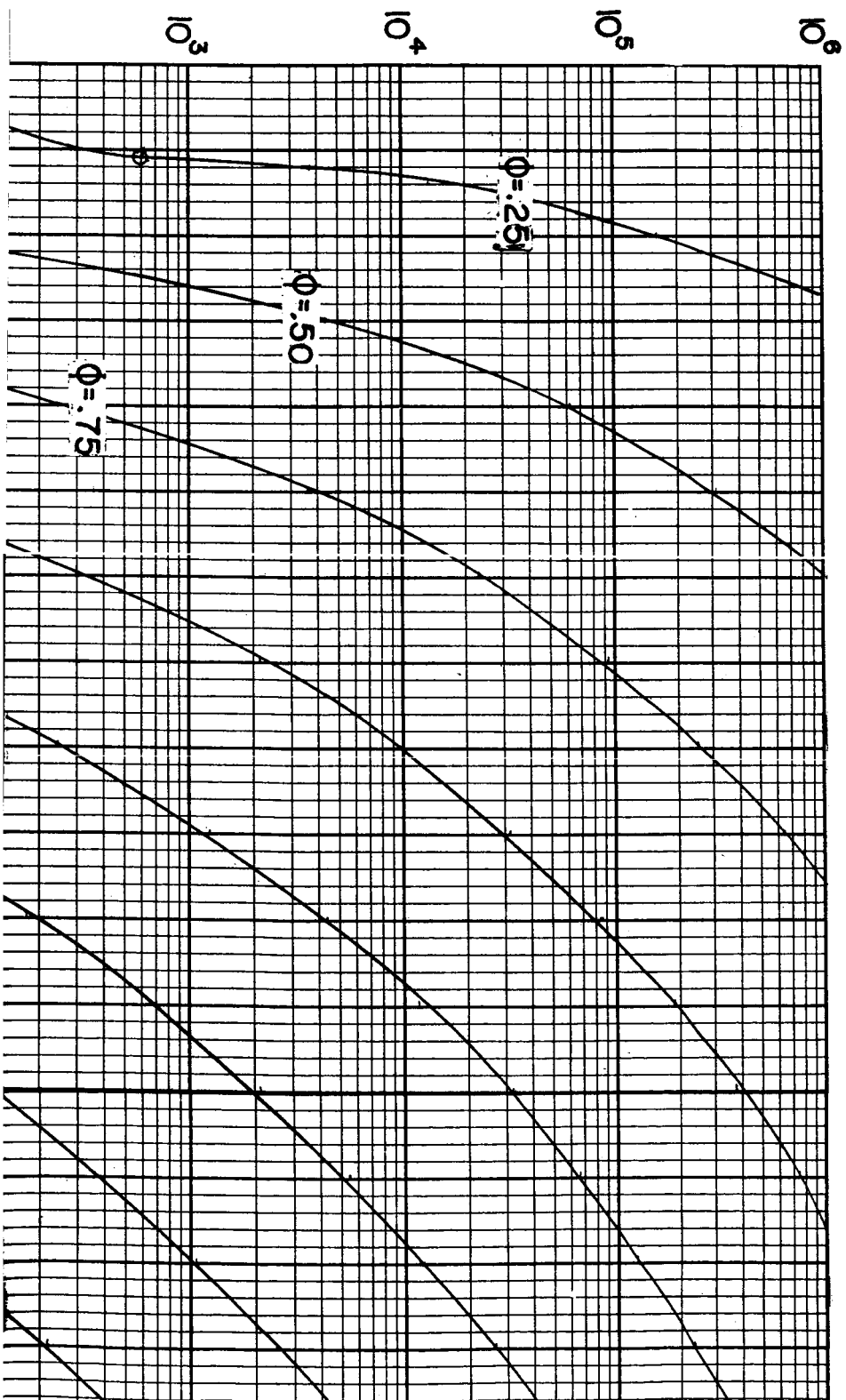


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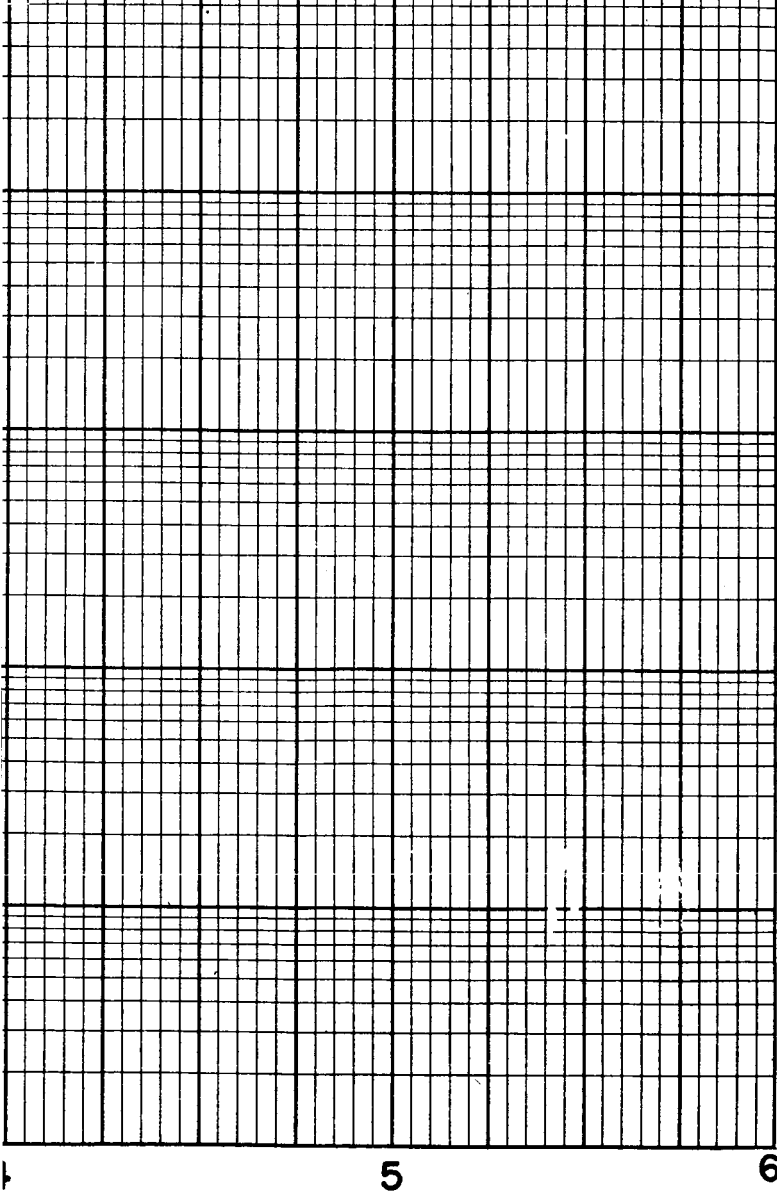
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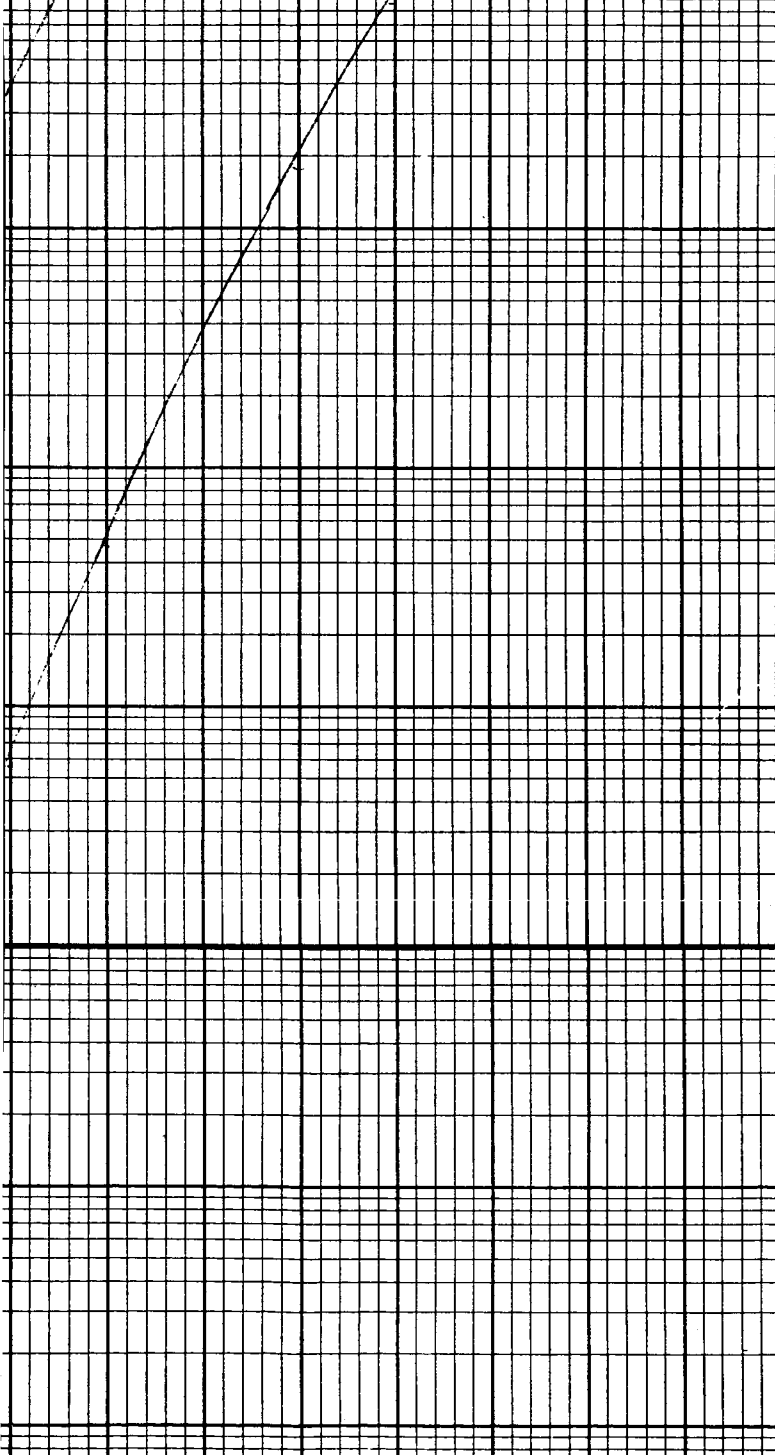


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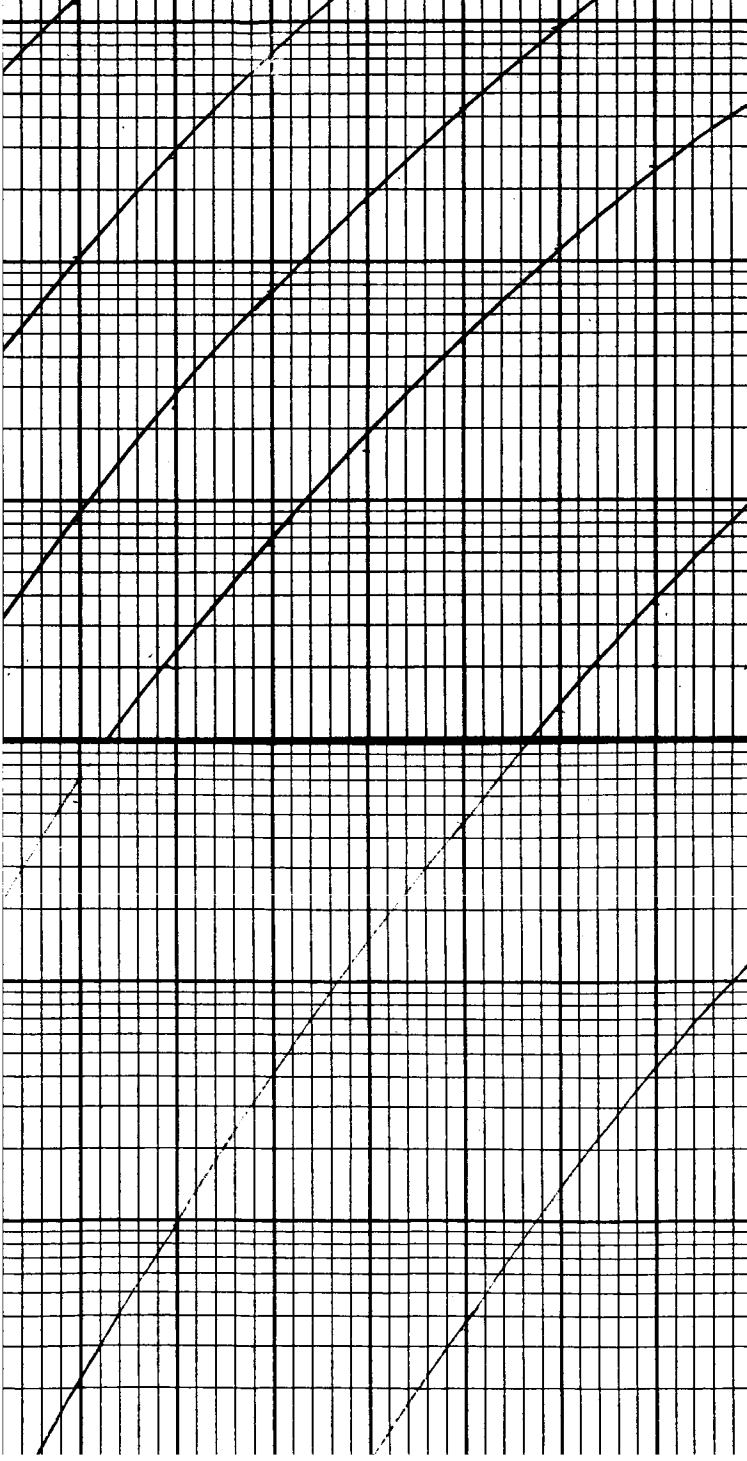


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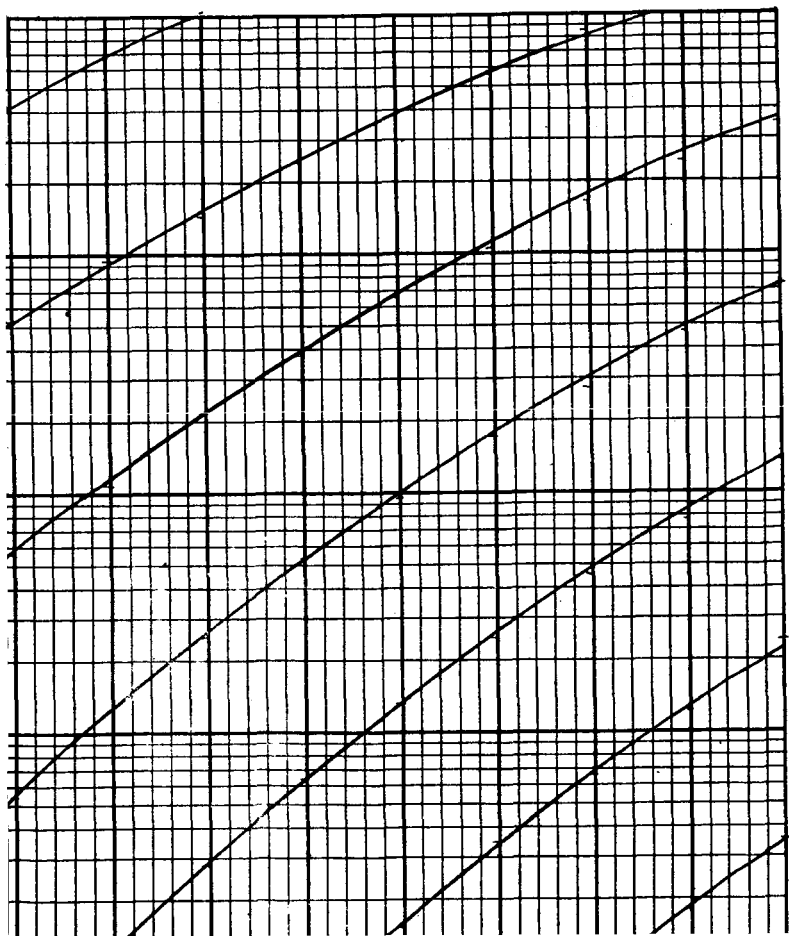




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